



Natural Resources and Environmental Pressures in Indian Ocean

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Abstract: The sea floor of the Indian Ocean and the continental margins bordering the ocean are covered by a wide variety of marine sediments and biogenous or anthigenic mineral deposits. The humid tropical climate of some of the land areas bordering the Indian Ocean accelerates weathering of the source rocks. This coupled with the large river runoff and wave and current conditions favor the formation of a variety of placer deposits. The biogenous deposits comprise the corals on shallow banks and on the

continental shelves and then oozes in the deep sea. The anthigenic deposits in the Indian Ocean comprise the phosphorites and the polymetallic modules. Occurrences of phosphorite deposits have been found both along continental margins and around seamounts. The mineral wealth of Indian Ocean is enormous and of greatest value. Being surrounded by developing countries, the Indian Ocean is being exploited far less as compared to minerals of other oceans.

Howsoever, the ocean is under pressure from human activities. These challenges are set to continue for the foreseeable future, with atmospheric CO² predicted to reach 430 ppm by 2030 and 750 ppm by 2100. The cycling of biogeochemical elements has proved sensitive to each of these effects, and it is proposed that synergy between stressors may compound this further. The challenge, within the next few decades, for the marine science community, especially in Indian Ocean is to elucidate the scope and extent that biological processes can adapt or acclimatize to a changing chemical and physical marine environment. Other dynamic trends that relate to the various industries include the IO's growing prominence in the world energy trade, piracy attacks that have led to challenges in maritime security, and environmental stresses brought on by marine and land-based waste and pollution.

Introduction to World Oceans

The **World Ocean** or **global ocean** (colloquially **the sea** or **the ocean**) is the interconnected system of Earth's oceanic waters, and comprises the bulk of the hydrosphere, covering almost **71%** of Earth's surface, with a total volume of **1.332 billion km³**. Of the major units that comprise the world ocean, three—the Atlantic, Indian, and Pacific oceans—extend northward from Antarctica as huge "gulfs" separating the continents. The fourth, the Arctic Ocean, nearly landlocked by Eurasia and North America and nearly circular in outline, caps the North Polar Region. The Southern Ocean (also called the Antarctic Ocean) is now often considered a fifth, Separate Ocean. The major oceans are further subdivided into smaller regions loosely called seas, gulfs, or bays.



Throughout history humans have been directly or indirectly influenced by the oceans. Ocean waters serve as a source of food and valuable minerals, as a vast highway for commerce, and provide a place for both recreation and waste disposal. Increasingly, people are turning to the oceans for their food supply either by direct consumption or indirectly by harvesting fish that is then processed for livestock feed. It has been estimated that as much as 10% of human protein intake comes from the oceans. Nevertheless, the food-producing potential of the oceans is only partly realized. Other biological products of the oceans are also commercially used. For example, pearls taken from oysters are used in jewelry, and shells and coral have been widely used as a source of building material.

→ Natural Resources found in Oceans

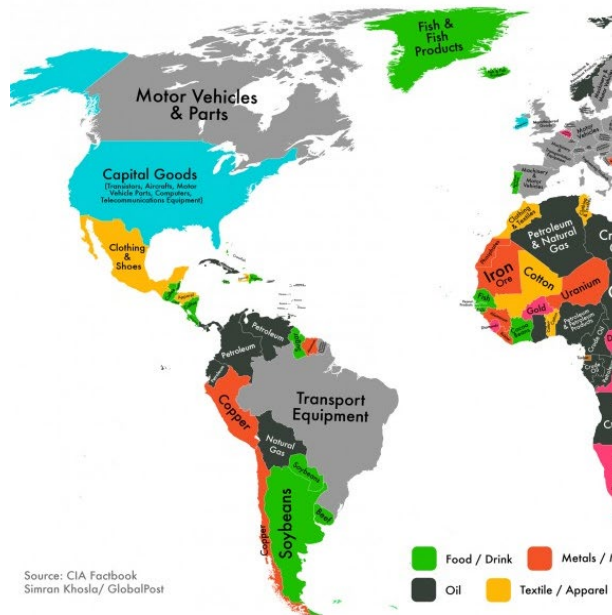
Our appetite for energy and mineral resources seems insatiable. As land based resources become increasingly scarce, those in the oceans are attracting greater interest. The **fuels and ores** in the deep sea are particularly tempting. But wind and wave power could also meet a proportion of our energy needs. **Oil and natural gas** are the key resources powering industrial societies. But deposits are dwindling and prices are rising. For this reason oil companies are turning their attention to resources which were previously thought too difficult and expensive to tap: the oil and gas deposits deep in the oceans. Already, more than a third of the oil and

gas extracted worldwide comes from offshore sources. Natural gas and oil have been extracted from the seas for decades, but the **ores and mineral deposits** on the sea floor have attracted little interest. Yet as resource prices rise, so too does the appeal of **ocean mining**. The excavation of massive sulphides and manganese nodules is expected to begin within the next few years. Until 10 years ago, hardly anyone had heard of **methane hydrates**¹. But now these chemical compounds in the sea floor are mooted to be an energy source of the future. The amount of hydrate-bound you far exceeds the reserves in conventional deposits. However, methane hydrates are not only a potential energy source; they also pose a considerable climate risk. Until now, the expansion of renewable energies, such as wind and solar power, has mainly taken place onshore. The energy in the oceans has remained largely untapped. But things are changing. The production of environmentally friendly **energy from the oceans** is now being promoted worldwide. As the expectations are high, it is hoped that wind, waves and ocean currents will meet a substantial share of the world's electricity needs.

A myriad of **minerals** including salt, copper, iron, manganese, nickel can be found are extracted from oceans. **Sand** used in constructions can be obtained from the sea. Then there is **fishing** of which the oceans' role is beyond description. Oceans equally play a key role in **transport**, acting as a medium for transport (shipping) of either goods in bulk, including oil, or passengers. They also serve an important purpose in **recreation/tourism**. Fun activities include sea voyages, sports, sunbathing at the beach, etc. Lastly, oceans are the largest carbon sink on earth. They absorb up to a third of the carbon emitted by human activities hence their importance in carbon sequestration, and thus climate change mitigation. It is thus difficult to quantitatively estimate the value of these resources given their scope so

¹ Methane hydrate is a crystalline solid that consists of a methane molecule surrounded by a cage of interlocking water molecules. Methane hydrate is an "ice" that only occurs naturally in subsurface deposits where temperature and pressure conditions are favorable for its formation.

all we can say is they are priceless.



Indian Ocean and its Superficial Resources

The Indian Ocean region is rapidly emerging as an essential crossroads linking the world's major producers and consumers of natural resources. Today, more than **two-thirds** of the world's oil passes through the region's waters, while **Australia, Indonesia, and South Africa** now account for more than half of global coal exports, shipping much of their product across the Indian Ocean to India, China, Japan, and South Korea, the world's top importers. In the coming decades, however, the natural riches beneath the sea will be as crucial to securing the region's future welfare as the commercial wealth travelling over the ocean waves.²

The significance of Indian Ocean is rising and strengthening because its littoral states possess more than **2/3** of world's oil reserves and roughly **35%** of world's gas reserves, **60%** of Uranium, **40%** of gold and **80%** of all diamond deposits. Indian Ocean is also important because of the industrial



² <https://www.stimson.org/content/under-sea-natural-resources-indian-ocean-0>

raw materials it possesses including lithium, nickel, cobalt, tin, manganese, phosphate etc.

The Indian Ocean's living resources represent one of the region's most significant assets. The Indian Ocean harbors an array of non-energy renewable and non-renewable resources. Various political, technological, and environmental factors affect the economic potential for developing these resources. Howsoever, the most commercially viable industries are fisheries and minerals.

❖ Fishery:

Commercial and artisanal fisheries sustain the livelihoods of more than **38 million** people worldwide.³ According to the United Nations Food and Agriculture Organization (FAO), catches from Indian Ocean marine capture fisheries have soared from less than **900,000 tons** in **1950** to **11.3 million tons** in **2010**, about **14.6 %** of the world catch, as a result of improvements in fish capture technology and rising demand caused by a growing global population. Aquaculture - farming fish, shellfish, and other aquatic animals in captivity - has expanded equally rapidly, growing twelve-fold globally since **1980**. In **2010**, six Indian Ocean nations - **India, Indonesia, Bangladesh, Thailand, Egypt, and Myanmar** - counted among the top ten producers worldwide, supplying over **11.3 million tons** of fish between them, as much as all the region's capture fisheries combined.

In recent years, the IO has produced approximately **10%** of the almost **93 million tons** of global fish production. But while other world oceans are nearing their fisheries limit, the United Nations Food and Agriculture Organization (FAO) judges that, in certain areas, the Indian Ocean's resources have the potential to sustain increased production.⁴

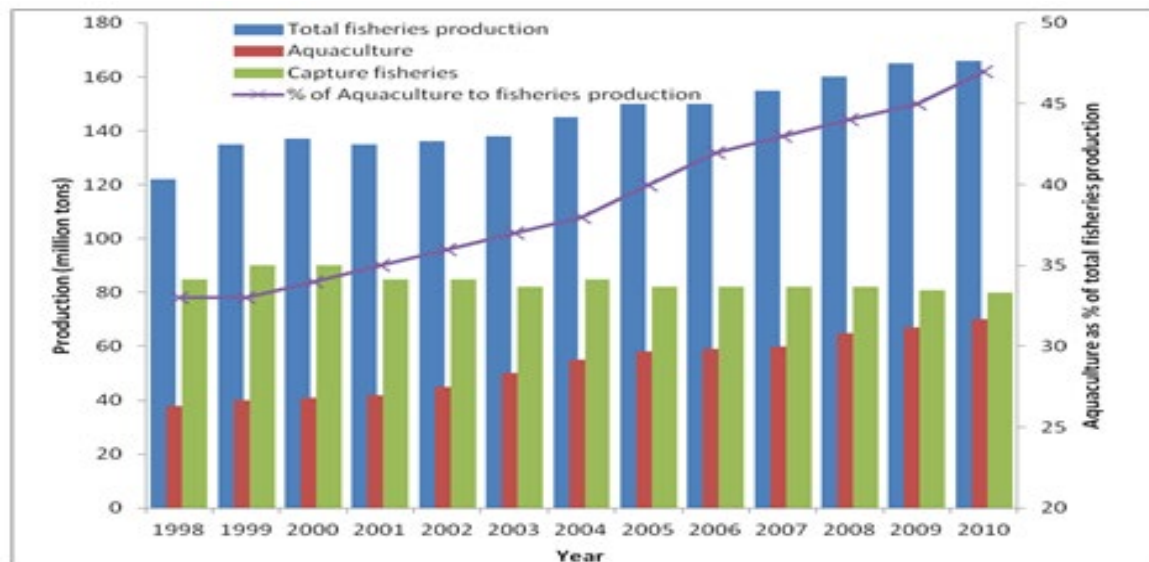
The countries of the **East Indian Ocean**⁵ represent a significant proportion of world fisheries, although most commercial and artisanal activity takes

³ Cassandra De Young (Ed.), "Review of the state of world marine capture fisheries management: Indian Ocean," Food and Agriculture Organization of the United Nations (FAO), 2006, <http://www.fao.org/docrep/009/a0477e/a0477e00.htm#Contents>

⁴ Ellen Laipson and Amit Pandya (Eds.), *The Indian Ocean: Resource and Governance Challenges* (Washington, DC: Stimson, 2009); FAO, *The State of World Fisheries and Aquaculture 2012* (Rome: 2012)

⁵ Small islands dot the continental rims. Island nations within the ocean are Madagascar (the world's fourth largest island), Bahrain, Comoros, Maldives, Mauritius, Seychelles and Sri Lanka. The archipelago of Indonesia and the island nation of East Timor border the ocean on the east.

place in coastal zones rather than in deep water.⁶ The East Indian Ocean is home to **45%** of the world's fishers and brings in catches of **7 million tons** of fish per year, or **8%** of total world fish production. Most of this catch is harvested close to shore, placing so much strain on coastal stocks that fishers have been forced to venture further out to sea and even into the exclusive economic zones (EEZs) of neighboring nations. Even so, this trend of fishing far from shore is still in its early stages. Deepwater catches represent less than **6%** of total catches in Indonesia and **10 %** in Malaysia, for example.⁷ Given the overexploitation and overcrowding of coastal fisheries, deepwater fish stocks represent a potential new frontier for commercial and artisanal fisheries in the region.



The West Indian Ocean is also characterized by overfishing and growing exploitation of deepwater fisheries.⁸ From **2000 to 2001** alone, total catches increased by **2.2 %**, representing a **10.6 %** increase over the previous decade.⁹ Most of this change has been driven by the increasing exploitation of deepwater fisheries by **non-littoral states** such as **Spain, Taiwan, Japan, France, and Uruguay**.¹⁰ The Western Indian Ocean

⁶ This region includes: Bangladesh, India, Indonesia, Malaysia, Myanmar, Sri Lanka, and Thailand.

⁷ De Young, 2006; FAO (2012)

⁸ This region includes: South Africa, Mozambique, Tanzania, Kenya, Madagascar, the Comoros Islands, the Maldives, Mayotte, Mauritius, Reunion, and Seychelles.

⁹ Rudy Van der Elst et al., "Fish, fishers and fisheries of the Western Indian Ocean: Their diversity and status," in *Philosophical Transactions: Mathematical, Physical and Engineering Sciences*, Vol. 363, No. 1826, 2005.

¹⁰ FAO Marine Resources Service, Fishery Resources Division, "Review of the state of world marine fishery resources," in FAO Fisheries Technical Paper, No. 457, 2005,

http://www.fao.org/fi/oldsite/eims_search/1_dett.asp?calling=simple_s_result&lang=en&pub_id=172962

(WIO) produces about **50%** of the IO landings, and the SWIO¹¹ region produces slightly over **10%** of the total WIO landings. Due to the overfishing of coastal stocks, many West Indian Ocean countries plan to expand their semi-industrial and industrial national fleets to new fishing grounds in their EEZs.

According to the FAO, most southwest Indian Ocean countries' fisheries have the potential to contribute a larger percent age of littoral states' GDP.¹²

The northwest Indian Ocean region has witnessed concerted government efforts to promote the fisheries industry, yet suffers from an overall lack of fisheries management.¹³ Many countries in the region offer subsidies to fishers in order to boost development. The results have been mixed, however. Despite significantly increased fishing since **1990**, actual catches have grown by only **12.3 %**. Catch limits are rare. Where they do exist, limits generally apply only to industrial fisheries, not the artisanal fishers who made up **80 %** of reported landings in **2002**. The absence of sustainable fisheries management policies and declining stocks has reduced both commercial and artisanal fisheries in the northwest Indian Ocean. In addition, oil fires and weapons debris have polluted the ocean in this conflict-prone region, further degrading its fisheries.

Australia is unique among the countries in the Indian Ocean region in that it has developed strict management controls and limits the exploitation of its fish stocks, resulting in a healthy fisheries industry. From **2000 to 2001**, the total fish catch from the Indian Ocean areas of Australia was **36,290 tons**, representing **15.8 %** of the total catch for Australian fisheries. About **651** commercial vessels and **28,000** artisanal fishers operated in Australia's Indian Ocean waters during this period. As a result of successful management policies, the number of fish stocks classified as overfished or at risk of overfishing dropped from **24** in **2005** to **18** in **2008**.¹⁴

❖ Minerals:

¹¹ The SWIO region includes five continental countries—Kenya, Mozambique, Somalia, South Africa, and Tanzania—and six islands and archipelagos—Comoros, Madagascar, the Maldives, Mauritius, Réunion (France), and the Seychelles.

¹² De Young, 2006.

¹³ This region includes: the Arabian Sea, the Persian Gulf, the Red Sea, the Gulf of Oman, and the Gulf of Aden.

¹⁴ FAO, *The State of World Fisheries and Aquaculture*, 2010, p. 42.

Polymetallic nodules and polymetallic massive sulphides are the two mineral resources of primary interest to developers in the Indian Ocean. **Polymetallic nodules** are golf-to-tennis ball-sized nodules containing nickel, **cobalt, iron, and manganese** that form over millions of years on the sediment of the seafloor. Typically found at four to five km in water depth, the nodules must be scooped up and brought to the surface. While polymetallic nodules cover vast plains, **polymetallic massive sulphides** form in highly localized sites—no bigger than a sports stadium—along hot springs in underwater volcanic ranges. “Massive” refers not to their size but to their mineral content, which contains **copper, iron, zinc, silver, and gold**.

Sulphides are formed when cold, heavy seawater descends deep into the earth’s crust and is heated by the magma. When the heated water buoyantly rises to the surface, it precipitates metals from the seawater and concentrates the minerals in deposits beneath and on the sea floor.

India received exclusive rights to explore polymetallic nodules in the Central Indian Ocean basin in **1987**. Since then, it has explored **four million square miles** and established **two mine sites**. To be commercially attractive, nodule deposits must have a content of nickel and copper of at least **2.25 %** and a nodule density of **10 kg per square meter**.¹⁵ Because of their gold content and greater copper composition, more recent commercial inquiries have focused on polymetallic massive sulphides. In **July 2011**, China was awarded the right to explore a **10,000 km² polymetallic sulphide** ore deposit in the Indian Ocean.

Other minerals in the Indian Ocean include **coastal sediments** containing titanium and zirconium off **South Africa** and **Mozambique**, and tin placer deposits¹⁶ off the coasts of **Myanmar, Thailand, and Indonesia**. South Africa is the second largest producer of titanium dioxide and zircon in the

¹⁵ Jan Magne Markussen, “Deep seabed mining and the environment: Consequences, perceptions, and regulations” in Helge Ole Bergeson and Georg Parmann (Eds.), *Green Globe Yearbook of International Cooperation on Environment and Development* (Oxford, UK: Oxford University Press, 1994), p. 31.

¹⁶ Placers may be defined as surficial mineral deposits formed by the mechanical concentration of mineral particles from weathered debris. The mechanical agent is usually alluvial, but can also be marine, aeolian, lacustrine, and glacial, and the mineral is usually heavy metal, such as gold. They are thus the deposits of gravel, sand or similar material resulting from the crumbling and erosion of solid rocks containing valuable minerals that have been derived from rocks or veins.

world, largely due to its heavy mineral sands. Tin dredged from this area amounts to **10 %** of world production and is worth about **\$100 million**.¹⁷

The sea-floor of Indian Ocean is covered by a wide variety of mineral deposits.

i. Beach Minerals from Indian Ocean:

Heavy minerals are reported from a number of locations on the beaches of Indian Ocean. These are called “placers”. The placer deposits of ilmeniet, zircon and monazite are found along the east coast of **South Africa**. Ilmeniet, zircon, monazite and rutile are also known from **Mozambique** and **Tanzania**. The beaches on the west of Indian Ocean have placers of ilmeniet, rutile, zircon, magnetite and garnet. The beaches of Sri Lanka are well known for placer deposits of ilmeniet, rutile, monazite and garnet and the total reserves are estimated to be about 4 million tones. The beaches and estuaries of Burma, Malaysia and Indonesia have large placers of tin and these contribute substantially to the world production of tin. Exploration has also confirmed the extension of these deposits into the offshore region.¹⁸

ii. Minerals of Living Organisms:

Large areas of seabed in Indian Ocean are covered by large deposits of biological materials. The calcareous deposits found in shallow areas of the continental shelf and on atolls and banks largely comprise corals and shells. The ideal conditions for the growth and formation of corals occur in warm tropical waters where there is limited discharge of fresh water and land run off; found particularly from Sumatra to Maldives, Madagascar and Red Sea. Deposits of calcareous shells also occur in the shallow areas of continental shelf. In some areas, the deposits are made up of fossil shells which get concentrated into large accumulation.¹⁹

iii. Minerals containing Phosphorus:

¹⁷ United Nations Division for Ocean Affairs and the Law of the Sea, Office of Legal Affairs and ISA, “Marine mineral resources: Scientific advances and economic perspectives,” 2004, p. 45.

¹⁸<https://books.google.com.pk/books?id=pzH1ZNJfY5cC&pg=PA80&lpg=PA80&dq=placer+deposits+in+indian+ocean&source=bl&ots=ohC9U-QCNN&sig=12hWsAD9KWaUS6oRBmQnIGnZONc&hl=en&sa=X&ved=0ahUKEwjHmlzSp-rSAhVMWBoKHZiOD-AQ6AEILjAF#v=onepage&q=placer%20deposits%20in%20indian%20ocean&f=false>

¹⁹ Ibid.

For the formation of phosphorites, there are several favorable areas in the Indian Ocean. The continental margins of East Africa, Southern Arabia, Western India and the Andaman's are marked by nutrient enrichment and some of these are also coincide with the disposition of phosphate and for favorable occurrence of phosphorites. Such deposits in some of these areas have been confirmed.

iv. Hydrothermal Minerals:

Hydrothermal mineral deposits²⁰ are found at the mid oceanic ridges and back arc basins. The Andaman Basin is typically a back-arc basin with a subduction zone having all the characteristic features of spreading ridge. In 2005, an enormous hydrothermal "mega-plume" was found in the Indian Ocean that serves as a dramatic reminder that underwater volcanoes likely play an important role in shaping Earth's ocean systems, scientists report. The plume, which stretches some **43.5 miles (70 kilometers)** long, probably caused by undersea volcanic eruptions, appears to be active on a previously unseen scale.

The appearance of hydrothermal vents²¹ around the world suggests that they are a far more common part of the ocean system than once believed and could be a major influence on circulation patterns and ocean chemistry.

❖ Oil and Natural Gas:

Oil and gas are the most valuable of all the minerals extracted from the sea bed. Most of the oil and gas producing areas of the oceans are confined to the continental shelf, but oil wells in much deeper seas have been dug in the recent past. At present half of the world's total output of oil and gas comes from offshore wells and over **75 countries** of the world are engaged in offshore drilling.

In the Indian Ocean, the major players in offshore oil and gas exploration, drilling and production are India, Gulf States and the Southeast Asian countries like Indonesia and Malaysia. Coastal areas of Australia (Western Australia) also have offshore oil reserves.

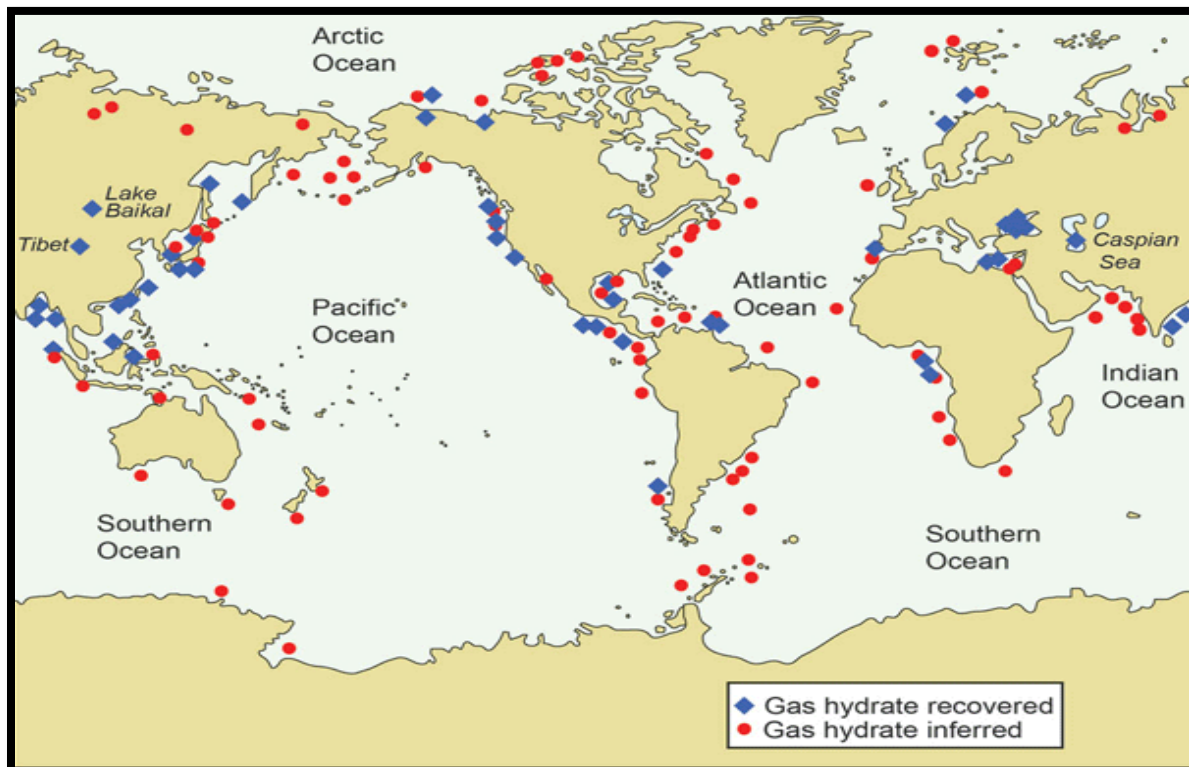
²⁰ Polymetallic sulphide deposits which contain strategic metals like zinc, copper, cobalt, silver etc.

²¹ Hydrothermal vents are volcanic hotspots that emit gasses and mineral-enriched water as hot as 760°F (400°C). The heat from these vents supports unique ecosystems where creatures survive using thermal and chemical energy in place of sunlight.

India has **3.2 lakh sq km** offshore areas of sedimentary deposits on the continental shelf upto a depth of **200 metres**. The Indus cone formed by the deposition of sediments by the Indus River encompasses the Kachchh Shelf, Gulf of Khambhat and Mumbai High. Mumbai High is the largest oil producer of India. Huge gas reserves have been found in the Krishna-Godavari basin off the coast of Andhra Pradesh.

Oil and gas reserves of the Persian Gulf are simply amazing. But these reserves remained unexploited for a pretty long time because this gulf has land based reserves also and those reserves were to be exploited first. The offshore potential is very important, especially for smaller states which have restricted land areas. The Persian Gulf has the advantage of being sheltered from the open ocean, is shallow and relatively free of hazards.

It is the most rapidly developing part of the industrialising world as its onshore and offshore wealth is re-invested in industry. Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates, Iran and Iraq are the likely beneficiary states.



In South-east Asian waters, offshore, oil is becoming increasingly significant for a number of countries in this vast archipelagic area. There is increasing shift from exploitation of land resources to offshore resources.

This phenomenon is particularly seen in Indonesia and Malaysia where the main producing areas are off southern Sumatra. The South-east Asian waters are considered as one of the most promising for immediate expansion.

Off the coast of Western Australia there are substantial reserves of oil and gas. These reserves experienced rapid development in the 1970s, besides there is great scope for harnessing the non-conventional energy resources in this ocean as well.²²

In **2016**, a large natural gas discovery, highly enriched accumulations of natural gas hydrate²³ — an icy form of the fuel — in the Bay of Bengal was made in the Indian Ocean following a joint expedition by India's Oil Ministry and the US Geological Survey opening up a new resource to meet energy needs. These gas hydrates discovered are located in coarse grained sand rich depositional systems in the Krishna-Godavari Basin and is made up of a sand rich, gas hydrate-bearing fan and channel-levee gas hydrate prospects.

❖ Petroleum deposits:

By far the most important of all marine resources is petroleum. Potentially important oil fields are being discovered every year in offshore areas. In similar ways, discoveries have been made in Indian Ocean region from Red Sea, Persian Gulf, Arabian Sea, Bay of Bengal, Indonesia Sea, West Australian Coastal areas, East and Southern African Coast and so on.²⁴

However the extent of offshore petroleum deposits cannot be determined easily, as it depends on the knowledge of the origin of petroleum and the factors required for its accumulation.

❖ Precious Metals:

²² <http://www.shortparagraph.com/natural-resources/paragraph-on-presence-of-oil-and-gas-in-indian-ocean/769>

²³ Natural gas hydrates are a naturally occurring, ice-like combination of natural gas and water found in oceans and polar- regions.

²⁴ https://link.springer.com/chapter/10.1007%2F978-3-642-95501-3_8#page-1

In **2015**, India launched its first seabed exploration for mineral deposits and precious metals in the southern Indian Ocean for deep exploration of polymetallic sulphides²⁵. Scientists surveyed the seabed and found deposits rich in copper, lead and zinc, as well as precious metals, including gold, silver, palladium and platinum.

And recently on **March 2, 2017**, Chinese first deep-sea manned submersible has collected a variety of precious metals in the northwestern Indian Ocean; evaluating the resource potential of the area. **Jiaolong**²⁶ collected **4.2 kg** of sulphide, **18.7 kg** of basalt and **16 liters** of deep-sea water besides testing all its systems while descending to a depth of **3,117 metres**.

As it developed the deep sea diving technology, China is stepping up exploration of the Indian Ocean, regarded as the backyard of India. China has already secured contracts from International Seabed Authority (ISA) in **2011**²⁷ to explore Indian Ocean for **polymetallic sulphide ore** and its research vessel has discovered **two hydrothermal areas** and **four hydrothermal anomaly** areas in southwest part of the ocean.

Similarly, last year (2016), around the same time another Chinese submersible **Qianlong No.2**²⁸ also completed its first exploration in the southwest Indian Ocean. The autonomous underwater vehicle (AUV) dived 16 times during the exploration in the southwest Indian Ocean and explored sea areas rich in sulfide deposits that contain various metals, detected deep-sea terrain as well as photographed sulfide, basalt and marine organisms.²⁹

❖ Mining and Environment:

Deep sea mining is a relatively new mineral retrieval process that takes place on the ocean floor. Ocean mining sites are usually around large

²⁵ Polymetallic sulphide commonly holds copper, iron and lead, besides gold and silver in lesser quantities.

²⁶ Jiaolong is a part of the 38th ocean scientific expedition.

²⁷ Under the contract with the ISA, China Ocean Mineral Resources Research and Development Association (COMRA) got exclusive rights to explore 10,000 square-km of seabed in the southwest Indian Ocean in an area off the coast of Africa.

²⁸ Qianlong No.2 was looking for sulphide deposits and precious metals.

²⁹ <http://www.dnaindia.com/scitech/report-china-s-submersible-finds-precious-metals-in-indian-ocean-2340047>

areas of polymetallic nodules or active and extinct hydrothermal vents at about 1,400 – 3,700 m below the ocean's surface.

Deep inside the ocean is a world as vibrant and rich as the one outside. There are mountain ranges, ridges, forests, seamounts, volcanoes and a unique ecology that defies common knowledge. For example, life here thrives without sunlight. This barely explored territory is also believed to hold vast quantities of precious metals and minerals that can sustain the modern world for centuries.

So when the International Seabed Authority (ISA) issued seven new licenses in the last week of **July 2014**, to explore for the riches that lie on the floors of the Pacific, Indian and Atlantic oceans, it sent ripples across the world. The UN body regulates exploitation of the ocean floor beyond **370-kilometre** territorial limits to prevent a free-for-all. Several governments and the mining industry that have their eyes on the underwater riches hailed the announcement, while scientists and environmentalists raised concerns about venturing into this unknown territory. Among others, two licenses are for the Indian Ocean Ridge.

The vast repository of minerals, including the precious cobalt, zinc, manganese and rare earth materials that are needed for smart phones, laptops and hybrid cars, are present in three forms of ore—polymetallic manganese nodules that remain strewn across the ocean floor; cobalt-rich ferromanganese crusts that cover the seamounts; and massive polymetallic sulphide deposits around hydrothermal vents³⁰. With the new license India has started looking for polymetallic sulphides that are rich in copper, zinc, gold and silver in the Indian Ocean Basin. And though there is no consolidated data on the mineral wealth underneath the high seas, studies suggest its richness. In the Indian Ocean, says the country's National Institute of Ocean Technology (NIOT), these nodules are strewn across **10-18 million sq km** of ocean floor. About **380 million tones** of nodules are present in the licensed exploration area of **150,000 sq km**. These include **92.60 million tones** of manganese. Minerals like cobalt, nickel and copper are present in the concentrations of **0.56, 4.70 and 4.30 million tones**. These metals are not available on the country's land. NIOT is developing

³⁰ These vents are cracks in volcanic areas of the ocean floor through which seeps iron- and sulphur-rich magma. As these minerals meet cold bottom water, they precipitate, creating high-grade deposits.

technologies for extracting these minerals from deep sea and has set up processing plants at the cost of **US \$135** million.

The Oceanic Problems:

The oceans are among our biggest resource for life on earth, and also our biggest dumping grounds. That kind of paradox could give anyone an identity crisis. We seem to think we can take all the goodies out and put all our garbage in, and then expect them to keep happily ticking away indefinitely. However, while it's true the oceans can provide us with some amazing eco-solutions like alternative energy, they're are undergoing some serious stress factors. Here are the seven biggest problems.

- Overfishing is draining the life from the water
- The ocean's most important predators being killed...but just for the fins
- Ocean acidification sending us back 35 million years
- Dying coral reefs and a scary downward spiral
- Ocean dead zones are everywhere, and growing
- Mercury pollution going from coal to oceans to fish to our dinner table
- The great pacific garbage patches a swirling plastic soup you can see from space.

The Environmental Pressures on Indian Ocean

The Indian Ocean rim region, home to around one-third of the world's population, possesses a significant strategic economic value. Nearly half the world's container traffic and 70% of the total traffic of petroleum products is accounted for by the Indian Ocean. 60,000 ships transit through

it each year. So, the geo-strategic significance of it is well established, and discussed extensively in strategic affairs forums. Yet, the environmental challenges facing the Indian Ocean, and the rim countries, often receive less attention.

Environmental issues can significantly affect the region's economic activities and environmental stability. While the natural environment in the Indian Ocean is faced with a plethora of threats, this post takes a quick look at some of the critical challenges which need to be addressed:

i. Ocean Resources:

The Indian Ocean possesses a range of valuable natural resources including sea minerals, coral reefs, etc. Coral reefs are under the threat of depletion due to global climate change, direct human pressures, and inadequate governance, awareness, and political will. Coastal ecosystems and recreational services provided by them play an important role in tourism, fisheries, livelihoods of coastal communities, etc., in the rim countries. Therefore, degradation of coastal ecosystems can have negative impacts on national economies. The region also possesses enormous amounts of economically valuable mineral resources and energy resources (both oil resources and renewable energy resources) which remain less exploited. Utilization of these resources needs to be done collaboratively by the rim countries as such activities can have detrimental impacts on the marine environment. Additionally, territorial claims by the rim countries and related political aspects also have become important concerns in the recent past with regard to natural resources usage as well as conservation in the Indian Ocean region.

ii. Climate Change:

The Indian Ocean region is highly vulnerable to the impacts of climate change. The region hosts a significant proportion of poor, living in areas highly vulnerable to various impacts of climate change. The countries have varying but limited capacity to cope with the impacts of climate change, which can come in the forms of extreme weather events, sea level rise, to name but a few. In addition, climate change is linked with other regional environmental issues - loss of biodiversity, for instance - which can have serious negative economic impacts on development in the region. Taking

adaptive measures to face the impacts of climate change remains one of the top development priorities for Indian Ocean rim countries.

iii. Bio-security:

Marine bio-security refers to the protection of marine environments from non-indigenous species, and this has direct implications on biodiversity in the marine ecological systems present in the Indian Ocean. It has been found that invasive alien species (IAS)³¹ are becoming a significant threat to marine biodiversity, where ballast water³² is viewed as a major cause of their proliferation. However, comprehensive studies on bio-security are rarely found in the case of the Indian Ocean, and it is becoming increasingly important to assess the marine bio-security risks for Indian Ocean rim countries. Structured and transparent evaluation techniques are needed in dealing with the issues related to bio-security, both in ecological and socio-political perspectives, supported with knowledge and resources to properly inform appropriate actions. Bio-security requires the cooperation of a range of actors including scientists, policy makers, law enforcement officials, etc., and therefore collaboration mechanisms as well as joint research and knowledge sharing on this subject at regional level are keys.

iv. Marine Pollution:

The Indian Ocean region is also vulnerable to high levels of pollution caused by ocean dumping, waste disposal and oil spills as a significant amount of international trade takes place in the region's waters. The wastes pose threats to the survival of marine organisms and consequently, on the marine ecosystem, on which millions of livelihoods depend. In addition, being bordered by fast growing economies such as India and China, as well as other East Asian economies, there is a high possibility of more industrial waste disposed to the ocean. Eutrophication of near-shore environments due to pollution from land-based sources and their run-off has impacted economic activities such as fisheries, tourism and also affected fragile ecosystems.

³¹ An invasive species is a species that does not naturally occur in a specific area and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

<http://www.invasivespecies.org/resources/DefineIS.html>

³² Ballast water is water carried by ships to ensure stability, trim and structural integrity. Sea water is used for this <http://globallast.imo.org/index.asp?page=problem.htm&menu=true>

V. Deep Sea Mining:

Adding to concerns about the disastrous decline in ocean ecosystems, now there is another emerging threat - deep sea mining. While shallow water mining for sand, gold, tin, and diamonds has been conducted for decades, commercial deep sea mining has yet to occur anywhere. But that's about to change.

In the oceans in general and in Indian Ocean in particular, environmental risks and impacts of deep sea mining would be enormous and unavoidable, including seabed habitat degradation over vast ocean areas, species extinctions, reduced habitat complexity, slow and uncertain recovery, suspended sediment plumes, toxic plumes from surface ore dewatering, pelagic ecosystem impacts, undersea noise, ore and oil spills in transport, and more.

→ Conclusion:

Although Indian Ocean is rich in natural resources and this is the very reason of its strategic significance for the global and regional powers in particular, yet the environmental pressures are leading the ocean to a number of misperceptions. Within inshore fisheries, challenges include overexploitation and related issues of stock collapse and change of inshore habitats, such as coral reefs and sea-grass beds. Conflicts between resource users, pollution of near-shore habitats, and global warming are the major threats. Of immediate concern are national and regional coordination in regulation, monitoring, and surveillance; the development and implementation of an early warning system for extreme events; and the enhancement of regional preparedness to deal with ocean-based disasters. Reduced productivity of fisheries and its negative impact on food security and economic activity are likely to increase cross-border conflicts and illegal marine economic activities, such as smuggling, piracy, and human trafficking, as those employed in the fishing industry seek other alternatives. The region is ill prepared to manage and adapt to the impacts of climate change and extreme events which threaten all coastal economic sectors, especially fisheries.

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